Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] 1. A reagent for use in oxidizing organic and inorganic compounds either in soil, sludge, groundwater, or wastewater comprising a reaction product produced by the process comprising the steps of:
a. Preparing a solid phase water soluble transition metal chelate; and
b. Combining said solid phase water-soluble transition metal chelate with a solid phase water-soluble peroxygen compound.

[c2] 2. A method for oxidizing organic and inorganic compounds either in soil, sludge, groundwater, or wastewater comprising the steps of:
a. Introducing a chelating agent or chelating agent/transition metal mixture in soil, sludge, groundwater, or wastewater to create a transition metal chelate in said soil, sludge, groundwater, or wastewater;
b. Introducing a solid phase water-soluble peroxygen compound to said soil, sludge, groundwater, or wastewater;
c. Using said transition metal chelate to catalytically decompose the peroxygen compound to produce free radi-

cals and other transient oxygen species; and
d. Oxidizing organic and inorganic compounds either in said soil, sludge, groundwater, or wastewater by the peroxygen compound or the free radical or transient oxygen species formed.

[c3] 3. The method as in Claim 2, wherein the oxidization of organic and inorganic compounds in said soil, sludge, groundwater, or wastewater is performed in situ.

[c4] 4. The method as in Claim 2, wherein the oxidization of organic and inorganic compounds in said soil, sludge, groundwater, or wastewater is performed ex situ.

[c5] 5. The method as in Claim 2, wherein the organic and inorganic compounds are at least one taken from the group consisting of volatile organic compounds, fuel oxygenates and associated degradation intermediates, semi-volatile organic compounds, polychlorinated biphenyls, oils, energetic compounds , manufactured gas plant wastes, wood preserving wastes, cations and anions.

[c6] 6. The method as in Claim 2, wherein the transition metal is at least one of ferrous iron, ferric iron, and ferrous sulfate.

[c7] 7. The method as in Claim 2, wherein the transition

metal is added to the soil, sludge, groundwater, or wastewater.

[c8] 8. The method as in Claim 2, wherein the transition metal selected is at least one that is naturally occurring in the soil, sludge, groundwater, or wastewater to be treated.

[c9] 9. The method as in Claim 8, wherein the naturally occurring transition metal is at least one taken from the group consisting of a soluble form of ferrous or ferric iron, an amorphous form of ferrous or ferric iron, and a solid form of ferrous or ferric iron.

[c10] 10. The method as in Claim 2, wherein the chelating agent is at least one taken from the group consisting of citric acid, STPP, EDTA, oxalic acid, HEDPA, NTA and hydroxyethyliminodiacetic acid.

[c11] 11. The method as in Claim 2, wherein the peroxygen compound is a persulfate.

[c12] 12. The method as in Claim 10, wherein the persulfate is at least one taken from the group consisting of a sodium base, ammonia base, and potassium base.

[c13] 13. A method for oxidizing organic and inorganic compounds either in soil, sludge, groundwater, or wastewa-

ter comprising the steps of adding a chelating agent followed by adding a solid phase peroxygen compound.

[c14] 14. The method as in Claim 13, wherein the peroxygen compound is added first followed by adding the chelating agent.

[c15] 15. The method as in Claim 13, wherein the chelating agent and the peroxygen compound are added simultaneously.

[c16] 16. The method as in Claim 13, wherein the chelating agent and the peroxygen compound are alternately added.

[c17] 17. The method as in Claim 2, wherein the chelating agent is first mixed with the transition metal and added to the soil, sludge, groundwater, or wastewater followed by addition of the peroxygen compound.

[c18] 18. The method as in Claim 17, wherein the peroxygen compound is added first followed by addition of the chelating agent/transition metal mixture.

[c19] 19. The method as in Claim 17, wherein the chelating agent/transition metal mixture and the peroxygen compound are added simultaneously.

[c20] 20. The method as in Claim 17, wherein the chelating

agent/transition metal mixture and the peroxygen compound are alternately added.

[c21] 21. The method as in Claim 2, wherein the said transition metal chelate is selected to provide for the slow release of ferrous or ferric iron into solution and the prolonged formation of free radicals and transient oxygen species such that at least some of the peroxygen compound remains for at least thirty days after being introduced.

[c22] 22. The method as in Claim 6, wherein the transition metal chelate and peroxygen compound system induces continuous cycling of iron between the ferrous and ferric states with co-production of free radicals and transient oxygen species until the supply of the peroxygen compound is exhausted.

[c23] 23. The method as in Claim 2, wherein the chelating agent, transition metal, and peroxygen compound are added as an aqueous solution.

[c24] 24. The method as in Claim 2, wherein the chelating agent, transition metal, and peroxygen are added as a solid phase water soluble compound.

[c25] 25. The method as in Claim 2, wherein the introducing steps are performed at ambient air, soil, sludge, ground-

water or wastewater temperature.

[c26] 26. The method as in Claim 2, wherein the introducing steps are performed at temperatures between 40° C and 100° C.

[c27] 27. The method as in Claim 2, further comprising the step of adjusting the acidity of the soil, sludge, groundwater, or wastewater prior to adding the chelating agent, transition metal, or peroxygen compound to a pH between 6 and 8.

[c28] 28. The method as in Claim 2, further comprising the step of adjusting the acidity of the soil, sludge, groundwater, or wastewater after adding the chelating agent, transition metal, or peroxygen compound to a pH between 6 and 8.

[c29] 29. The method as in Claim 2, wherein soil, sludge, groundwater, or wastewater has a soil oxidant demand, and the peroxygen compound at least partially satisfies the soil oxidant demand.

[c30] 30. A method to increase the mass transfer of organic compounds to groundwater, wastewater or the water phase of soil and sludge comprising the steps:
a. Introducing a chelating agent or chelating agent/ transition metal mixture in soil, sludge, groundwater or

wastewater to create a transition metal chelate in said soil, sludge, groundwater, or wastewater;

b. Introducing a solid phase water-soluble peroxygen compound to said soil, sludge, groundwater, or wastewater;

c. Using said transition metal chelate to catalytically decompose the peroxygen compound to produce free radicals and other transient oxygen species; and

d. Oxidizing said organic and inorganic compounds in said soil, sludge, groundwater, or wastewater by the peroxygen compound or the free radical or other transient oxygen species formed.

[c31] 31. The method as in Claim 30, wherein the organic compound is present as a non-aqueous phase liquid and the rate of dissolution to the aqueous phase is increased due to co-solvency effects of reaction by-products.

[c32] 32. The method as in Claim 30, wherein the oxidation of organic compounds in the aqueous phase increases the rate of organic contaminant desorption from soil into the aqueous phase.

[c33] 33. The method as in Claim 30, wherein the peroxygen compound directly attacks and breaks down natural organic compounds that are present in soil, sludge, groundwater, or wastewater thereby liberating the or-

ganic compounds previously sorbed to the natural organic matter to the aqueous phase.

[c34] 34. A method to enhance the biological degradation of organic compounds in soil, sludge, groundwater, or wastewater comprising the steps of:
a. Introducing a chelating agent or chelating agent/ transition metal mixture in soil, sludge, groundwater, or wastewater to create a transition metal chelate in said soil, sludge, groundwater, or wastewater;
b. Introducing a solid phase water-soluble peroxygen compound to said soil, sludge, groundwater, or wastewater;
c. Using said transition metal chelate to catalytically decompose the peroxygen compound to produce free radicals and other transient oxygen species; and
d. Oxidizing said organic compounds either in soil, sludge, groundwater, or wastewater by the peroxygen compound or the free radical or transient oxygen species formed.

[c35] 35. The method as in Claim 34, wherein an electron donor is provided for stimulating the growth of indigenous microorganisms known to degrade organic compounds to innocuous end products.

[c36] 36. The method as in Claim 35, wherein the electron

donor is the organic compound which has been desorbed from soil and hence is more bioavailable.

[c37] 37. The method as in Claim 35, wherein the electron donor is a bioavailable form of partially degraded or oxidized organic contaminant or partially degraded natural organic carbon.

[c38] 38. The method as in Claim 35, wherein the electron donor is an un-reacted chelating agent.

[c39] 39. The method as in Claim 35, wherein the electron donor is a byproduct of a reacted chelating agent.

[c40] 40. The method as in Claim 35, wherein the indigenous microorganisms degrade the organic compounds to innocuous end products through metabolic, co-metabolic, or reductive processes.

[c41] 41. The method as in Claim 40, wherein said process is dechlorination.

[c42] 42. The method as in Claim 34, wherein an electron acceptor is provided for stimulating the growth of indigenous microorganisms known to degrade organic compounds to innocuous end products.

[c43] 43. The method as in Claim 42, wherein the electron acceptor is sulfate and the class of indigenous microor-

ganisms stimulate are sulfate-reducing bacteria.

[c44] 44. The method as in Claim 42, wherein the electron acceptor is oxygen and the class of indigenous microorganisms stimulated is aerobic heterotrophic bacteria.

[c45] 45. A method for oxidizing vapors and odors arising from the excavation of contaminated soil, sludge, groundwater or wastewater comprising the steps of:
a. Introducing a chelating agent or chelating agent/ transition metal mixture in contaminated soil, sludge, groundwater, or wastewater to create a transition metal chelate in said soil, sludge, groundwater, or wastewater;
b. Introducing a solid phase water-soluble peroxygen compound to said soil, sludge, groundwater, or wastewater;
c. Using said transition metal chelate to catalytically decompose the peroxygen compound to produce free radicals and other transient oxygen species; and
d. Oxidizing said organic compounds either in soil, sludge, groundwater, or wastewater by the peroxygen compound or the free radical or transient oxygen species formed.